

## 1 ABSTRACT

2 Composite media having simultaneous negative effective  
3 permittivity and permeability over a common band of frequencies. A composite  
4 media of the invention combines media, which are either themselves separately  
5 composite or continuous media, having a negative permittivity and a negative  
6 permeability over a common frequency band. Various forms of separate  
7 composite and continuous media may be relied upon in the invention. A preferred  
8 composite media includes a periodic array of conducting elements that can behave  
9 as an effective medium for electromagnetic scattering when the wavelength is  
10 much longer than both the element dimension and lattice spacing. The composite  
11 media has an effective permittivity  $\epsilon_{\text{eff}}(\omega)$  and permeability  $\mu_{\text{eff}}(\omega)$  which are  
12 simultaneously negative over a common set of frequencies. Either one or both of  
13 the negative permeability and negative permittivity media used in the invention  
14 may be modulable via external or internal stimulus. Additionally, the medium or a  
15 portion thereof may contain other media that have medium electromagnetic  
16 parameters that can be modulated. The frequency position, bandwidth, and other  
17 properties of the left-handed propagation band can then be altered, for example, by  
18 an applied field or other stimulus. Another possibility is the use of a substrate  
19 which responds to external or internal stimulus.